# The mortality associated with review by the rapid response team for non-arrest deterioration: a cohort study of acute hospital adult patients

Roger J Smith, John D Santamaria, David A Reid and Espedito E Faraone


## ABSTRACT

**Objectives:** To compare the admission characteristics, discharge destination and mortality of patients reviewed by the rapid response team (RRT) for deterioration with those of other hospital patients; and to determine the association between RRT review for deterioration and mortality.

**Design, setting and patients:** Acute admissions of adult patients to a tertiary hospital between 1 January 2008 and 31 December 2011 were identified from administrative data. Data for each patient's first admission were merged with RRT data on the first RRT event of each admission, if any. RRT events involving cardiac arrest were classified as arrest events and all others as deterioration events.

**Results:** Of 43 385 patients in the cohort, 1117 (2.57%) had RRT review for deterioration and 91 (0.21%) for cardiac arrest. Deterioration events occurred a median of 3.23 days after admission. Advanced treatments were instituted in 38.59% of deterioration events, and a new not-for-resuscitation order for 5.55%. Compared with those not reviewed by the RRT, patients in the deterioration group were older (median, 70 v 60 years, $P < 0.001$) and had a higher Charlson comorbidity index (median, 1 v 0, $P < 0.001$). They also more often died in hospital (18.80% v 1.42%, $P < 0.001$) or were discharged to another hospital (37.51% v 13.39%, $P < 0.001$) and more often died in the 90 days after admission (24.44% v 3.48%, $P < 0.001$). Their adjusted odds ratio of death in the 90 days after admission was 5.85 (95% CI, 4.97–6.89, $P < 0.001$).

**Conclusion:** Patients reviewed for deterioration were older and had greater comorbidity than patients the RRT was not called to review. RRT review for deterioration was an independent risk factor for mortality.


Crit Care Resusc 2014; 16: 119–126

Fewer than 20% of people who suffer cardiac arrest in hospital survive to hospital discharge.[1,2] Rapid response teams (RRTs) have been introduced with the rationale that early intervention in the care of patients with unexpected clinical deterioration might prevent serious adverse events.[3] A body of literature now exists suggesting that RRTs reduce serious adverse events, particularly cardiac arrests outside intensive care.[4-12] However, many studies evaluating RRTs have not sought to describe the admission characteristics or outcomes of the patients seen by RRTs[4-12] and, although RRTs are now employed in many hospitals,[12] there is limited information about the characteristics and outcomes of patients they review. A recent study across 35 Australian centres found 24% of patients assessed by an RRT died in hospital, but the characteristics of the patients and the reasons for RRT attendance were not available.[13] Downey and colleagues examined two cohorts of 100 patients who received RRT review for altered conscious state and arrhythmias and found hospital mortality was 35% and 18%, respectively.[14] The study illuminated two important subgroups of patients seen by RRTs, but more information is required to understand who receives RRT review and what happens to these patients. The aims of our study were: to compare the admission characteristics, discharge destination and mortality in the 90 days after admission of patients reviewed by the RRT for non-arrest deterioration with those of patients not reviewed by the RRT; and to determine the association between RRT review for non-arrest deterioration and mortality.

## Methods

### The hospital and its rapid response system

St Vincent's Hospital is a tertiary hospital for adult patients that is affiliated with the University of Melbourne and situated on the edge of the Melbourne central business district. During the study period (2008–2011), the hospital had about 300 acute ward beds and provided a comprehensive range of medical and surgical subspecialties, including cardiac surgery and neurosurgery, but did not perform solid organ transplantation, other than renal transplantation, and did not provide major trauma or burns services.

Commencing in 2002 and continuing throughout the study period, two types of rapid response operated at the hospital: Respond Blue and Respond Medical Emergency Team (MET). These services were available 24 hours a day, seven days a week. Activation (calling) criteria are shown in

Figure 1 and are the same as those used in the MERIT study,[7] but with an additional criterion: $SpO_2 < 90\%$ despite supplemental oxygen. Respond MET personnel comprised a medical registrar, intensive care registrar and an intensive care nurse. The Respond Blue team consisted of the MET personnel and an anaesthetic registrar.

The project was approved by St Vincent's Hospital (Melbourne) Human Research Ethics Committee on 1 August 2012 (ref. QA 044/12). The committee waived the requirement to obtain patient consent.

### Hospital administrative data

The hospital's administrative database (PAS; CSC) was maintained by trained personnel to permit accurate reporting of the diagnoses and vital outcome of every hospital separation to government health authorities. In December 2012, information relating to all admissions to the hospital between 1 January 2008 and 31 December 2011 was extracted from the database. The information

**Figure 1. Rapid response team calling criteria**

| |
|---|
| **Respond Blue** |
| Threatened airway |
| Respiratory arrest |
| Cardiac arrest |
| **Respond Medical Emergency Team** |
| Respiratory rate < 5 breaths per minute |
| Respiratory rate > 36 breaths per minute |
| $SpO_2 < 90\%$ despite supplemental oxygen |
| Pulse rate < 40 beats per minute |
| Pulse rate > 140 beats per minute |
| Systolic blood pressure < 90 mmHg |
| Unexpected deterioration in conscious state |
| Repeated or prolonged seizures |
| Staff seriously concerned |

**Table 1. Demographic and hospital admission characteristics, by group**

| | Stable group ($n = 42\,177$) | Deterioration group ($n = 1117$) | | Cardiac arrest group ($n = 91$) | |
|---|---|---|---|---|---|
| | Number (%)* | Number (%)* | $P^\dagger$ | Number (%)* | $P^\dagger$ |
| Age, years, median (IQR) | 60 (42–73) | 70 (56–79) | < 0.001 | 70 (62–78) | < 0.001 |
| Age group | | | | | |
| < 60 years | 20 657 (48.98%) | 357 (31.96%) | < 0.001 | 14 (15.38%) | < 0.001 |
| 60–79 years | 15 961 (37.84%) | 507 (45.39%) | < 0.001 | 58 (63.74%) | < 0.001 |
| ⩾ 80 years | 5 559 (13.18%) | 253 (22.65%) | < 0.001 | 19 (20.88%) | 0.042 |
| Male | 23 716 (56.23%) | 637 (57.03%) | 0.60 | 61 (67.03%) | 0.044 |
| Non-surgical treating unit | 16 983 (40.27%) | 569 (50.94%) | < 0.001 | 55 (60.44%) | < 0.001 |
| Treating unit | | | | | |
| General medicine | 5 311 (12.59%) | 267 (23.90%) | < 0.001 | 18 (19.78%) | 0.06 |
| Cardiology | 4 777 (11.33%) | 73 (6.54%) | < 0.001 | 31 (34.07%) | < 0.001 |
| Haematology and oncology | 912 (2.16%) | 48 (4.30%) | < 0.001 | 2 (2.20%) | 0.73 |
| Stroke | 674 (1.60%) | 44 (3.94%) | < 0.001 | 1 (1.10%) | 1.00 |
| Other medicine specialty | 5 309 (12.59%) | 137 (12.26%) | 0.78 | 3 (3.30%) | 0.004 |
| General surgery | 6 226 (14.76%) | 111 (9.94%) | < 0.001 | 7 (7.69%) | 0.06 |
| Orthopaedic surgery | 5 276 (12.51%) | 80 (7.16%) | < 0.001 | 3 (3.30%) | 0.004 |
| Neurosurgery | 3 769 (8.94%) | 180 (16.11%) | < 0.001 | 8 (8.79%) | 1.00 |
| Cardiothoracic surgery | 2 146 (5.09%) | 81 (7.25%) | 0.002 | 16 (17.58%) | < 0.001 |
| Other surgery specialty | 7 777 (18.44%) | 96 (8.59%) | < 0.001 | 2 (2.20%) | < 0.001 |
| Charlson CI, median (IQR) | 0 (0–1) | 1 (0–3) | < 0.001 | 1 (0–2) | < 0.001 |
| Charlson CI, 0 | 27 226 (64.55%) | 346 (30.98%) | < 0.001 | 23 (25.27%) | < 0.001 |
| Charlson CI, 1–4 | 13 093 (31.04%) | 645 (57.74%) | < 0.001 | 62 (68.13%) | < 0.001 |
| Charlson CI, ⩾ 5 | 1 858 (4.41%) | 126 (11.28%) | < 0.001 | 6 (6.59%) | 0.30 |
| Days in hospital, median (IQR) | 3.2 (1.3–7.2) | 13.7 (7.2–26.8) | < 0.001 | 6.6 (1.8–16.6) | < 0.001 |

IQR = interquartile range. CI = comorbidity index. * Unless otherwise stated. † Compared with the stable group. Contingency tables were assessed using the Fisher exact test and continuous variables using the Wilcoxon rank-sum test.

**Table 2. Discharge destination and mortality outcomes, by group**

| | Stable group ($n = 42\,177$) | Deterioration group ($n = 1117$) | | | | Cardiac arrest group ($n = 91$) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number (%) | Number (%) | *P** | Odds ratio (95% CI)† | *P** | Number (%) | *P** | Odds ratio (95% CI)† | *P** |
| Hospital discharge destination | | | | | | | | | |
| Home | 35 337 (83.78%) | 463 (41.45%) | < 0.001 | 0.14 (0.12–0.15) | < 0.001 | 19 (20.88%) | < 0.001 | 0.05 (0.03–0.08) | < 0.001 |
| Another hospital | 5 648 (13.39%) | 419 (37.51%) | < 0.001 | 3.88 (3.43–4.40) | < 0.001 | 14 (15.38%) | 0.54 | 1.18 (0.66–2.08) | 0.58 |
| Residential aged care | 594 (1.41%) | 25 (2.24%) | 0.029 | 1.60 (1.07–2.40) | 0.022 | 1 (1.10%) | 1.00 | 0.78 (0.11–5.59) | 0.80 |
| Died in hospital | 598 (1.42%) | 210 (18.80%) | < 0.001 | 16.10 (13.58–19.09) | < 0.001 | 57 (62.64%) | < 0.001 | 116.57 (75.65–179.61) | < 0.001 |
| Died in the 90 days after admission | 1 469 (3.48%) | 273 (24.44%) | < 0.001 | 8.96 (7.75–10.37) | < 0.001 | 57 (62.64%) | < 0.001 | 46.46 (30.28–71.27) | < 0.001 |

* Compared with the stable group. Contingency tables were assessed using the Fisher exact test. † Logistic regression was used to calculate odds ratios.

included sex, age at admission, ward of admission and discharge, treating unit, date and time of admission and discharge, discharge destination and date of death. Day cases and emergency department (ED) cases were excluded. Day cases were defined as those where the patient was admitted to and discharged from a day-investigation or day-treatment area and the length of stay was less than 12 hours. ED cases were defined as those where the patient was admitted to and discharged from the ED and was under the care of ED physicians throughout. Information relating to each patient's first hospital visit during the study period was retained in the final dataset.

Date of death was known for deaths that occurred at the hospital or that were reported to the hospital. The study hospital was in the same health care group as several of the facilities to which many of its patients were discharged, had relationships with many of the general practitioners who cared for discharged patients in the community, and operated a large outpatient clinic. These factors assisted the hospital to maintain records of the deaths of patients that occurred outside the hospital, but it was not mandatory for external deaths to be reported to the hospital. Linkage to a national or regional register of deaths was not performed.

Each patient's Charlson comorbidity index (CI)[15] was calculated using diagnoses that had been classified according to the *International statistical classification of diseases and related health problems, 10th revision, Australian modification* (National Casemix and Classification Centre, Wollongong, NSW) and assigned at hospital discharge by the hospital's clinical coding department.

### Rapid response team event data

Intensive care registrars completed an audit form for every attendance by the RRT (an RRT event). Intensive care research nurses checked the forms against the patients' medical records to ensure completeness. A log of calls to the hospital paging system was also checked to ensure all RRT events were identified. Every event was discussed with the Director of Critical Care Medicine (J D S) during weekly meetings. The information collected included the date, time and location of the event; the reasons given by clinicians for activating the system, classified according to the calling criteria; the occurrence of cardiac arrest; and the interventions performed. RRT events that involved cardiac arrest were classified as arrest events, and all others as deterioration events. Information relating to the first RRT event of the hospital visit was retained in the final dataset.

### Statistical analysis

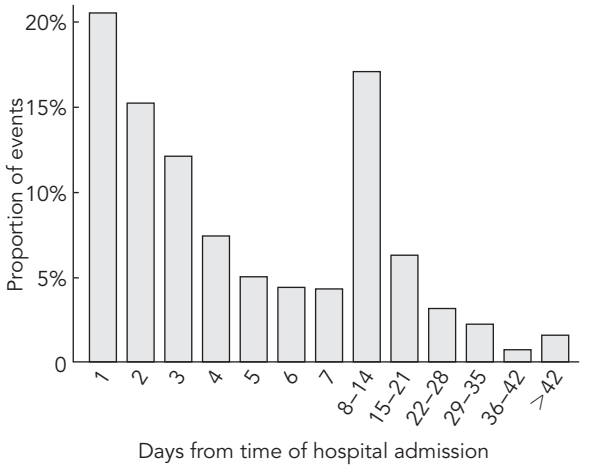
Patients who were not reviewed by the RRT at any time were assigned to the "stable" group, while those whose first RRT event was a deterioration event were assigned to the "deterioration" group and those whose first RRT event was an arrest event to the "cardiac arrest" group. Categorical variables are reported as counts with percentages. Continuous variables did not have normal distributions and are expressed as medians with interquartile ranges (IQRs). We used univariate analyses to compare the deterioration group with the stable group, and the cardiac arrest group with the stable group. Differences between continuous variables were assessed using the Wilcoxon rank-sum test, and contingency tables were assessed using the Fisher exact test. Simple logistic regression was used to

**Table 3. Onset, location, reason for call and interventions for first deterioration event ($n = 1117$)**

| Characteristic of event | Number (%)* |
|---|---|
| Days from admission to event, median (IQR) | 3.23 (1.19–9.18) |
| Outside usual work hours† | 723 (64.73%) |
| Location of the patient | |
| General ward | 975 (87.29%) |
| Coronary care unit | 52 (4.66%) |
| Medical imaging | 35 (3.13%) |
| Day procedures | 13 (1.16%) |
| Cardiac catheter laboratory | 10 (0.90%) |
| Other procedure or investigation area | 18 (1.61%) |
| Other area | 14 (1.25%) |
| Reason for RRT review‡ | |
| Airway threatened | 64 (5.73%) |
| Respiratory arrest | 14 (1.25%) |
| Respiratory rate < 5 breaths per minute | 14 (1.25%) |
| Respiratory rate > 36 breaths per minute | 119 (10.65%) |
| $SpO_2$ < 90% despite supplemental oxygen | 264 (23.63%) |
| Heart rate < 40 beats per minute | 39 (3.49%) |
| Heart rate > 140 beats per minute | 157 (14.06%) |
| Systolic blood pressure < 90 mmHg | 264 (23.63%) |
| Unexpected deterioration in conscious state | 346 (30.98%) |
| Repeated or prolonged seizures | 55 (4.92%) |
| Number of reasons for RRT review | |
| None of the reasons listed above | 116 (10.38%) |
| One of the reasons listed above | 698 (62.49%) |
| Two or more of the reasons listed above | 303 (27.13%) |
| Advanced interventions§ | |
| Endotracheal intubation | 64 (5.73%) |
| Inotrope or vasopressor administration | 79 (7.07%) |
| Antiarrhythmic drug administration | 111 (9.94%) |
| Transfusion of packed red blood cells or whole blood | 70 (6.27%) |
| Transfer to another area | 278 (24.89%) |
| One or more advanced interventions | 431 (38.59%) |
| Transfer destination | |
| Intensive care unit | 151 (13.52%) |
| Coronary care unit | 49 (4.39%) |
| Procedure area (eg, theatre, angiography) | 55 (4.92%) |
| Other area | 23 (2.06%) |
| NFR order in place before the event | 123 (11.01%) |
| NFR order put in place at the time of the event | 62 (5.55%) |
| Duration of event, minutes, median (IQR) | 20 (15–35) |

IQR = interquartile range. RRT = rapid response team. NFR = not for resuscitation. * Unless otherwise stated. † Outside usual work hours refers to 18:00–07:59 Monday–Friday and any time on Saturday or Sunday. ‡ More than one reason for RRT review could be recorded for a single event (eg, "Respiratory rate > 36 breaths per minute" and "$SpO_2$ < 90% despite supplemental oxygen"). However, "Respiratory arrest" and "Respiratory rate < 5 breaths per minute" could not both be given — the most appropriate criterion was identified. § More than one advanced intervention could be performed per event.

**Figure 2. Time from hospital admission to rapid response team review for first deterioration event ($n = 1117$)***




* Days constitute consecutive 24-hour periods from the time of hospital admission.

explore associations between group allocation and binary outcome variables. Multivariable logistic regression was used to determine the adjusted odds ratio of death in the 90 days after hospital admission for patients who recorded a deterioration event or an arrest event. The following prespecified variables that were considered to be potential confounders were included in the model and then, beginning with the least important explanatory variable, omitted using backward elimination if its $P$ value was > 0.1: calendar year of hospital admission, age group (< 60 years, 60–79 years or ⩾ 80 years), male sex, admission under a non-surgical treating unit, and Charlson CI group (0, 1–4 or ⩾ 5). The first category of each variable provided the reference point. $P$ values < 0.05 were taken to signify statistical significance. Analyses were performed using Stata, version 12.1 (StataCorp).

## Results

There were 43 385 patients in the cohort: 42 177 (97.22%) were not seen by the RRT at any time during their hospital visit (the stable group). The first RRT event of the hospital visit was a deterioration event for 1117 patients (2.57%) (the deterioration group), and a cardiac arrest for 91 patients (0.21%) (the cardiac arrest group).

The demographic and admission characteristics of the patients in each group are shown in Table 1, and the hospital discharge destination and mortality in the 90 days after hospital admission for each group are shown in Table 2.

**Table 4. Characteristics and hospital mortality of cardiac arrest events, by event location ($n = 91$)**

| | General ward ($n = 48$) | CCU and cardiac catheter laboratory ($n = 29$) | Other area ($n = 14$) | $P$* |
|---|---|---|---|---|
| Days from admission to event, median (IQR) | 5.87 (2.12–11.72) | 0.44 (0.10–1.24) | 1.12 (0.37–2.61) | < 0.001 |
| Initial rhythm VT or VF | 10 (21%) | 14 (48%) | 2 (14%) | 0.022 |
| Hospital mortality | 36 (75%) | 12 (41%) | 9 (64%) | 0.012 |

CCU = coronary care unit. VT = ventricular tachycardia. VF = ventricular fibrillation. * Contingency tables were assessed using the Fisher exact test and the continuous variable using the Kruskal–Wallis test.

### Deterioration ($n = 1117$)

The deterioration group was older than the stable group, with significantly larger proportions aged 60–79 years (45.39% v 37.84%, $P < 0.001$) or ⩾ 80 years (22.65% v 13.18%, $P < 0.001$), and had more comorbidities, indicated by significantly larger proportions with Charlson CIs of 1–4 (57.74% v 31.04%, $P < 0.001$) or ⩾ 5 (11.28% v 4.41%, $P < 0.001$) (Table 1). Differences also existed between the groups in relation to the treating units, with the deterioration group having significantly larger proportions admitted under general medicine (23.90% v 12.59%, $P < 0.001$), haematology and oncology (4.30% v 2.16%, $P < 0.001$), stroke (3.94% v 1.60%, $P < 0.001$), neurosurgery (16.11% v 8.94%, $P < 0.001$) and cardiothoracic surgery (7.25% v 5.09%, $P = 0.002$).

**Table 5. Multivariable logistic regression model of mortality in the 90 days after hospital admission***

| | Odds ratio (95% CI) | $P$ |
|---|---|---|
| RRT review status | | |
| Not reviewed | 1.00 | — |
| Reviewed for deterioration | 5.85 (4.97–6.89) | < 0.001 |
| Reviewed for cardiac arrest | 39.44 (24.78–62.76) | < 0.001 |
| Charlson comorbidity index | | |
| 0 | 1.00 | — |
| 1–4 | 3.74 (3.27–4.27) | < 0.001 |
| ⩾ 5 | 20.65 (17.65–24.16) | < 0.001 |
| Age group | | |
| < 60 years | 1.00 | — |
| 60–79 years | 2.16 (1.88–2.49) | < 0.001 |
| ⩾ 80 years | 5.66 (4.89–6.56) | < 0.001 |
| Treating unit | | |
| Surgical | 1.00 | — |
| Non-surgical | 1.75 (1.57–1.94) | < 0.001 |
| Sex | | |
| Female | 1.00 | — |
| Male | 1.12 (1.01–1.25) | 0.031 |

RRT = rapid response team. * Observations = 43 385. Area under the receiver operating characteristic (ROC) curve, 0.86.

Characteristics of the first deterioration event for each patient in the deterioration group in relation to timing, location, reasons for calling the RRT and interventions instituted by the RRT are shown in Table 3. The median number of days from hospital admission to the deterioration event was 3.23 (IQR, 1.19–9.18). Just over a third of the events occurred within 48 hours of admission, about another third occurred 3–7 days after admission and the remaining third more than 1 week after admission (Figure 2). The patient was on a general ward in the overwhelming majority of cases (87.3%). Other reported locations of the events included a procedure or investigation area (6.8%) and the coronary care unit (4.7%). The most common reasons for requesting RRT review, noting that more than one reason may be given for an event, were an unexpected deterioration in conscious state (31.0%) and $SpO_2 < 90\%$ despite supplemental oxygen (23.6%). One of the criteria for activating the RRT (excluding "staff concern/other") was present in 62.5% of cases, and two or more criteria were present in 27.1%.

Interventions that could be regarded as "advanced" were often performed in response to deterioration events (Table 3). This included endotracheal intubation in 64 cases (5.7%), inotrope or vasopressor administration in 79 (7.1%), antiarrhythmic drug administration in 111 (9.9%), transfusion of packed red blood cells or whole blood in 70 (6.3%), and transfer of the patient to another area of the hospital in 278 cases (24.9%). Any one or more of these interventions was performed in 431 cases (38.6%). For patients who were transferred, the most common destinations were the intensive care unit (54.3%), a procedure area (19.8%) and the coronary care unit (17.6%). A not-for-resuscitation (NFR) order was already in place for 123 patients (11.0%) and an NFR order was put in place as part of the management of the event for another 62 (5.6%). Median duration of the event (ie, the period of attendance by RRT personnel) was 20 minutes (IQR, 15–35).

Many patients were discharged from hospital to another acute or subacute hospital but the proportion was significantly larger for the deterioration group compared with the stable group (37.51% v 13.39%, $P < 0.001$) (Table 2). The deterioration group also had significantly larger proportions who died in hospital (18.80% v 1.42%, $P < 0.001$) and who died in the 90 days after admission (24.44% v 3.48%, $P < 0.001$).

Of the 123 patients in the deterioration group for whom an NFR order was already in place at the time of the deterioration event, 78 had died by 90 days after admission, which accounted for 28.6% of all the deaths that occurred in the deterioration group by that time.

### Cardiac arrest ($n = 91$)

The median age in the cardiac arrest group was 70 years (IQR, 62–78) and 61 patients (67.03%) were male (Table 1). Fifty-seven patients (62.64%) died in hospital (Table 2). Almost a third of the arrest events occurred in a cardiac specialty area (the coronary care unit or the cardiac catheter laboratory), and these events had different characteristics and outcomes to those that occurred on the general wards (Table 4). The initial rhythm was ventricular tachycardia or ventricular fibrillation in 48% of cases in the cardiac specialty areas, compared with only 21% for those on the general wards. Hospital mortality was 41% for patients who arrested in a cardiac specialty area, but 75% for those on a general ward.

### Multivariable analysis

The final multivariable model is shown in Table 5. The area under the receiver operating characteristic (ROC) curve was 0.86, indicating that the capacity of the model to distinguish between survivors and non-survivors was reasonable. Adjusting for age group, male sex, admission under a non-surgical unit and Charlson CI group, the odds ratio of death in the 90 days after hospital admission for the deterioration patients, compared with those who were never seen by the RRT, was 5.85 (95% CI, 4.97–6.89, $P < 0.001$) and for the cardiac arrest patients it was 39.44 (95% CI, 24.78–62.76, $P < 0.001$). Charlson CI $\geqslant 5$ and age $\geqslant 80$ years were also strongly associated with, and had a large effect on, mortality.

### Recurrent deterioration and event rates

Although we analysed only the first RRT event for each patient, it was common for these patients to be seen by the RRT more than once during their hospital visit. Among the 1117 patients in the deterioration group, 248 (22.20%) were seen by the RRT for deterioration on at least one further occasion and 20 (1.79%) were seen subsequently by the RRT for cardiac arrest. Among the 91 patients in the cardiac arrest group, there were five (5.49%) who were seen by the RRT for cardiac arrest on at least one further occasion and nine (9.89%) who were seen subsequently for deterioration.

The 43 385 patients in the cohort accumulated a total of 268 078 hospital days, 1509 deterioration events (5.63 per 1000 hospital days) and 117 cardiac arrest events (0.44 per 1000 hospital days).

## Discussion

In this cohort study of acute hospital adult patients, we found that deterioration occurred in about one in 40 patients. Almost 20% of these patients died in hospital and nearly 40% were discharged to continue hospital care elsewhere. Compared with those who did not receive RRT review at any time, patients reviewed for deterioration were older, had more comorbidity and were more likely to be admitted under a non-surgical unit. We found that RRT review for deterioration was a strong and independent risk factor for death (odds ratio, 5.85).

There are at least two factors that could explain the association between RRT review for deterioration and mortality. The first is the severity of the deterioration. Although they were not in cardiac arrest, the patients in the deterioration group displayed serious clinical signs, and more than one of the criteria for triggering RRT review were present in over a quarter of cases. The acuity and complexity of the patients' conditions is highlighted by the nature of the interventions performed and by the time invested: one or more treatments that could be regarded as "advanced" were instituted by the RRT for almost 40% of the deterioration group, and in 25% of cases, the RRT was in attendance for 35 minutes or longer. The second factor relates to the long period of hospitalisation that commonly preceded the deterioration events. Over half the deterioration events occurred when the patient had already received more than 3 days of acute hospital care. The distribution of deterioration events we observed (where about a third occurred in the first 48 hours after admission, a third 3–7 days after admission, and a third more than 1 week after admission) is very similar to that reported in a recent multicentre study.[16] That study found activation of the RRT system after 7 days in hospital was associated with significantly higher hospital mortality compared with activation during the first 2 days of the admission. It is possible that, by the time of RRT review, patients have well established acute organ dysfunction, which is difficult to reverse.

The hospital mortality of patients reviewed by the RRT for deterioration was almost 20%, broadly in keeping with the hospital mortality rate for these patients reported at other Australian centres.[13,14] In addition to the severity of the

deterioration and the long period of hospitalisation that typically preceded the events, the advanced age and significant comorbidities of a considerable proportion of the patients might also help explain the high mortality rate. Given that 11% of patients in the deterioration group had a Charlson CI $\geqslant 5$ and that 23% were aged 80 years or older, it is perhaps not surprising that 11% had an NFR order in place at the time of the deterioration event and that another 6% had an NFR order put in place as part of the event's management. Rapid deterioration and death should not be regarded as inevitable for all patients for whom there is an NFR order; nor does the existence of an NFR order imply that the RRT cannot make a positive contribution to the care of the patient.[17,18] However, the substantial proportion of patients who either had or required an NFR order draws attention to the serious underlying health problems that were present among many of the patients who had a deterioration event. Some patients reviewed by the RRT for deterioration may simply have been dying as a natural consequence of age and comorbidity.

A limitation of this study is that the deaths of patients that occurred outside the hospital were only known if they were reported to the hospital, which was not mandatory. Consequently, the figures for mortality in the 90 days after hospital admission are almost certainly underestimates, and we cannot exclude the possibility of a systematic difference between the groups in the way deaths were reported. Despite this limitation, the study sheds important light on the short-term mortality of acute hospital patients. In absolute terms, the proportion of deaths in the 90 days after admission was higher than those occurring in hospital by at least 5.64% for the patients who had RRT review for deterioration and at least 2.06% for those who were not seen by the RRT. Hospital mortality appears to understate the extent of the short-term mortality in this population.

This study did not examine the underlying cause of the abnormal clinical signs that triggered review by the RRT (eg, sepsis, pulmonary oedema). Others have found that a relatively small number of "syndromes" drive a large proportion of RRT events[19] and that the type of syndrome can affect the patient's outcome.[14] Our analysis may have been more instructive if the deterioration events had been classified according to the underlying problem. Also, we chose to study only the first RRT event for each patient, as it was assumed that the first event would shape the subsequent clinical course. Given how common it is for more than one deterioration event to occur during a hospital visit, the effect of additional events on patient outcomes warrants further investigation.

It should be recognised that, as this was a single-centre study, hospitals that have different RRT systems, a different culture or attitude towards deterioration or a different mix of patients might observe different results. The study hospital's RRT had been in place for more than 5 years before the study commenced and all staff received training about the system. Also, in the years preceding the study, we reported an increase in the RRT activation rate and a decrease in the cardiac arrest rate, suggesting that the system had matured.[10] This gives us confidence that, in general, the system was activated when the calling criteria were met.

In summary, deterioration that prompts attendance by the RRT is an independent risk factor for mortality. The RRT functions as a rescue service for patients with serious clinical problems who have very often already received several days of hospital care. Many of the patients the RRT reviews are in older age groups and have significant underlying health problems. Clinicians, including those in the parent units of patients on general hospital wards, should avoid thinking that RRTs can easily reverse serious deterioration. Developing complementary strategies to prevent deterioration and to recognise and respond to it at its earliest stages seems sensible. Anticipating terminal decline, recognising deterioration that is irreversible and setting appropriate goals of care in these situations are important skills for acute care clinicians.

## Acknowledgements

We wish to thank Ms Jennifer Holmes for her contribution to maintenance of the RRT database, Dr Antony Tobin for critically appraising the manuscript and the registrars of the Department of Critical Care Medicine for assisting with the data collection. We also wish to recognise all the doctors and nurses who, with skill and dedication, provide the RRT service.

## Competing interests

None declared.

## Author details

**Roger J Smith,** Research Coordinator
**John D Santamaria,** Associate Professor and Director
**David A Reid,** Data Analyst
**Espedito E Faraone,** Research Coordinator
Department of Critical Care Medicine, St Vincent's Hospital, Melbourne, VIC, Australia.
***Correspondence:*** roger.smith@svhm.org.au

## References

1 Meaney PA, Nadkarni VM, Kern KB, et al. Rhythms and outcomes of adult in-hospital cardiac arrest. *Crit Care Med* 2010; 38: 101-8.
2 Peberdy MA, Kaye W, Ornato JP, et al. Cardiopulmonary resuscitation of adults in the hospital: a report of 14720 cardiac arrests from the National Registry of Cardiopulmonary Resuscitation. *Resuscitation* 2003; 58: 297-308.
3 Jones DA, DeVita MA, Bellomo R. Rapid-response teams. *N Engl J Med* 2011; 365: 139-46.

4 Bristow PJ, Hillman KM, Chey T, et al. Rates of in-hospital arrests, deaths and intensive care admissions: the effect of a medical emergency team. *Med J Aust* 2000; 173: 236-40.

5 Bellomo R, Goldsmith D, Uchino S, et al. A prospective before-and-after trial of a medical emergency team. *Med J Aust* 2003; 179: 283-7.

6 DeVita MA, Braithwaite RS, Mahidara R, et al. Use of medical emergency teams to reduce hospital cardiopulmonary arrests. *Qual Saf Health Care* 2004; 13: 251-4.

7 Hillman K, Chen J, Cretikos M, et al. Introduction of the medical emergency team (MET) system: a cluster-randomised controlled trial. *Lancet* 2005; 365: 2091-7.

8 Jones D, Bellomo R, Bates S, et al. Long term effect of a medical emergency team on cardiac arrests in a teaching hospital. *Crit Care* 2005; 9: R808-15.

9 Buist M, Harrison J, Abaloz E, Van Dyke S. Six year audit of cardiac arrests and medical emergency team calls in an Australian outer metropolitan teaching hospital. *BMJ* 2007; 335: 1210-2.

10 Santamaria J, Tobin A, Holmes J. Changing cardiac arrest and hospital mortality rates through a medical emergency team takes time and constant review. *Crit Care Med* 2010; 38: 445-50.

11 Chan PS, Jain R, Nallmothu BK, et al. Rapid response teams: a systematic review and meta-analysis. *Arch Intern Med* 2010; 170: 18-26.

12 Jones D, George C, Hart GK, et al. Introduction of medical emergency teams in Australia and New Zealand: a multi-centre study. *Crit Care* 2008; 12: R46.

13 ANZICS-CORE MET Dose Investigators. Mortality of rapid response team patients in Australia. *Crit Care Resusc* 2013; 15: 273-8.

14 Downey AW, Quach JL, Haase M, et al. Characteristics and outcomes of patients receiving a medical emergency team review for acute change in conscious state or arrhythmias. *Crit Care Med* 2008; 36: 477-81.

15 Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chron Dis* 1987; 40: 373-83.

16 Medical Emergency Team End-of-Life Care Investigators. The timing of Rapid-Response Team activations: a multicentre international study. *Crit Care Resusc* 2013; 15: 15-20.

17 Jones DA, Bagshaw SM, Barrett J, et al: The role of the medical emergency team in end-of-life care: a multicenter, prospective, observational study. *Crit Care Med* 2012; 40: 98-103.

18 Jones DA, McIntyre T, Baldwin I, et al. The medical emergency team and end-of-life care: a pilot study: *Crit Care Resusc* 2007; 9: 151-6.

19 Jones D, Duke G, Green J, et al. Medical emergency team syndromes and an approach to their management. *Crit Care* 2006; 10: R30. ❑